STATE OF CALIFORNIA

AIR RESOURCES BOARD

AIR MONITORING QUALITY ASSURANCE

VOLUME V

AUDIT PROCEDURES
FOR
AIR QUALITY MONITORING

APPENDIX D

PERFORMANCE AUDIT PROCEDURES
FOR
HIGH VOLUME SAMPLERS

MONITORING AND LABORATORY DIVISION

OCTOBER 2002

TABLE OF CONTENTS

PERFORMANCE AUDIT PROCEDURES
FOR
HIGH VOLUME SAMPLERS

APPENDIX D

FIGURES AND TABLE

PERFORMANCE AUDIT PROCEDURES
FOR
HIGH VOLUME SAMPLERS

APPENDIX D

PAGE

Figures

Table

STATE OF CALIFORNIA

AIR RESOURCES BOARD

AIR MONITORING QUALITY ASSURANCE

VOLUME V

AUDIT PROCEDURES
FOR
AIR QUALITY MONITORING

APPENDIX D.1

PERFORMANCE AUDIT PROCEDURES
FOR
HIGH VOLUME SAMPLERS

MONITORING AND LABORATORY DIVISION

OCTOBER 2002

D.1.0 INTRODUCTION

D.1.0.1 GENERAL AUDITING PROCEDURES

The primary goal of an auditing program is to identify system errors that may result in suspect or invalid data. The absolute efficiency of the monitoring system (labor input versus valid data output) is contingent upon effective quality assurance procedures.

This true assessment of the accuracy and efficiency of the High Volume (Hi-Vol) particulate measurement system can only be achieved by conducting an audit under the following guidelines:

A. Without special preparation or adjustment of the system to be audited.

B. By an individual with a thorough knowledge of the instrument or the process that is being evaluated, but not by the routine operator.

C. With accurate calibrated National Institute of Standards Technology (NIST) traceable transfer standards that are completely independent of those used in routine calibration.

D. With complete documentation of audit data for submission to the operating agency. Audit information includes, but is not limited to, types of instruments and audit transfer standards, model and serial numbers, transfer standard traceability, calibration information, and collected audit data.

An independent observer should be present, preferably the routine operator of the sampling equipment. This practice not only contributes to the integrity of the audit, but also allows the operator to offer any explanations and information that will help the auditor to determine the cause of discrepancies between measured audit data and the sampling equipment response.

D.1.0.2 FLOW RATE AUDITING PROCEDURES

Audit procedures provided here are specific to Hi-Vol samplers that are equipped with fractionating inlets that require an actual flow rate of 1.1 to 1.7 m^3/min (39.0 to 60.0 CFM). Audit techniques may vary among different models of samplers because of differences in required flow rates, flow controlling devices, options utilized (i.e., continuous flow recorder), and the configuration of the sampler. In this subsection, the following conditions are assumed:

A. The volumetric flow rate, at the sampler inlet, is designed to operate in the range of 1.1 to 1.7 m^3/min (39.0 to 60.0 CFM) at actual conditions. In some cases the actual flow rate must be corrected in relationship to the elevation of the site (see Table D.1.2.1).

B. The calibrated transfer standard will be a BGI variable orifice equipped with a differential pressure gauge. This equipment is NIST traceable and certified once a quarter with the standard deviation within 1.0% of the last two certifications.

C. The audit orifice calibration relationship is expressed in terms of the true volumetric flow rate (Qc) as indicated by the audit orifice; these units being ft3/min [Cubic Feet per Minute (CFM)].

D. The type of sampler used for particulate measurement is provided in Figure D.1.2.1.

D.1.1 AUDIT EQUIPMENT

Performance audits of High Volume Samplers requires the following equipment:

A. A calibrated (NIST traceable) orifice device with the most recent calibration report.

B. A differential pressure gauge with a range of 0-10" of H_2O and a minimal scale division of at least 0.2 inches.

C. A thermometer capable of accurately measuring temperature in the range of -20°C to +60°C and accurate to the nearest 1°C. It must be referenced to an NIST or ASTM thermometer and be checked annually. The thermometer should be within ±2°C on the annual check.

D. A barometer capable of accurately measuring ambient pressures to the nearest millimeter of mercury (mm Hg) in the range of 500 to 800 mm Hg. The barometer must be referenced within ±5 mm Hg of a barometer traceable to NIST at least annually.

E. Quality Assurance Audit PM10 and TSP Worksheet (Figure D.1.2.2).

F. Spare recorder charts, clean filters, and miscellaneous hand tools.

NOTE: The site operator is responsible for providing the sampler's calibration relationship (calibration curve or factor) for the subsequent determination of the Hi-Vol sampler's actual flow rate (Qa).

D.1.2 FLOW RATE PERFORMANCE AUDIT PROCEDURES FOR HIGH VOLUME SAMPLERS

When conducting an audit of the high volume (Hi-Vol) particulate sampler, the following procedures should be adhered to:

A. On the blank side of a clean recorder chart, record the following parameters:

1. Sampler ID number.

2. Site name.

3. Site number.

4. Date.

5. Auditor's initials.

B. Open the front door of the sampler and install the clean, annotated chart in the recorder.

NOTE: Use operator's chart if possible to eliminate error due to different brand variation in the chart printing. If the Hi-Vol sampler was calibrated by using square root function paper, the audit must be conducted with a similar recorder chart. Observe the recorder zero setting. Ask the operator if they normally adjust the zero as part of their weekly routine. If they do, instruct them to adjust the pen to indicate true zero.

C. Install a clean filter in the Hi-Vol sampler. **DO NOT** use a filter cassette; place the filter directly on the sampler filter screen.

D. Install the faceplate and audit orifice on the sampler. Do not restrict the flow rate through the orifice (i.e. by using plates or closing the valve). Use an unrestricted orifice. Simultaneously tighten the faceplate nuts on alternate corners to prohibit leaks and to assure even tightening. The fittings should be hand-tightened; too much compression can damage the sealing gasket. Make sure the orifice gasket is present and the orifice is not cross-threaded on the faceplate.

NOTE: The sampler inlet may be partially lowered, within 2 inches, over the audit orifice to act as a draft shield.

E. Inspect the differential pressure gauge for the correct zero and adjust if necessary.

F. Switch on the sampler and allow it to warm up to operating temperature (3 to 5 minutes).

G. Observe and record the following parameters on the Quality Assurance PM10 and TSP Worksheet (Figure D.1.2.2):

1. Site name, site number and date.

2. Site address and agency.

3. Technician and auditors.

4. Sampler make, model and ID number.

5. Sampler designation - NAMS, SLAMS, OTHER etc.

6. Last calibration date and Magnahelic reading.

7. EPA equivalency number and results of flow controller test Ambient barometric

8. Cal Equip. Cert. Date, calibration Slope and Intercept.

9. Barometric pressure (Pa) in mm Hg. and Ambient temperature (Ta) in degrees Centigrade (°C).

H. When the sampler has warmed up to operating temperature, read the pressure deflection across the orifice by reading the differential pressure gauge and record as ΔP on the audit worksheet.

I. Ask the operator to read the corresponding recorder response and record it on the worksheet as the sampler's indicated flow rate (Qind).

NOTE: Make sure the operator relieves the recorder pen drag by tapping the side of the recorder and rotating it before reading the chart. This ensures a true reading.

J. Switch off the sampler until zero is attained and repeat Steps H and I, of D.1.2, two more times to give you a total of three observations.

K. If the sampler is not utilizing a mass flow controller, repeat steps H through J, of D.1.2, two more times at different flow rates. The flow rate is adjusted using the audit orifice.

NOTE: If sampler is audited at three flow rates, each flow rate is an individual audit and is recorded as such on the worksheet. The three audits will be checked for accuracy, but only the unrestricted flow responses will be used in the report generation. The flow-restricted results will be recorded in the comment section.

L. If the sampler is utilizing a mass flow controller, confirm the flow controller and motor is operating properly. Run the sampler with one filter in place and mark the recording device (chart recorder). Without turning off the sampler, partially close the valve on the audit orifice and check that the flow drops and returns to the original operating point within several minutes. Then without turning off the motor, reopen the valve on the audit orifice and check again for over-shoot and verify that the flow again returns to the original operating point. If the flow controller and motor are not responding to this type of systems check, then a double filter test is performed. Remove the audit orifice and allow sampler to reach normal operating conditions with a filter in place. The flow controller is tested by the addition and removal of a second filter to the system. Check again for the correct flow responses and document the information on the Quality Assurance Worksheet (Figure D.1.2.2).

NOTE: In the event the sampler does not pass the flow controller tests notify the technician of equipment failure and document any needed information.

M. Gather all audit data, including the audit orifice calibration information, the Hi-Vol sampler's calibration data (calibration curve), and the recorder chart that graphically displays the sampler response.

N. Verify the correct calibrator and sampler recorder responses have been written on the worksheet.

O. Ask the operator to calculate the sampler's standard flow rate (Qstd) as determined by the calibration relationship and record on the worksheet.

P. If the standard flow rate is Qstd, convert Qstd to Qa (actual flow) by using Equation 1:

$$Qa = Qstd \times \frac{760}{Pa} \times \frac{Ta}{298.15} \qquad \text{(Eq. 1)}$$

Where:

Qa = Sampler's actual flow rate

Qstd = Sampler's standard flow rate

Ta = ambient temperature, °K (°K = °C + 273.15)

Pa = ambient barometric pressure, mm Hg

NOTE: Subsections P thru S are generated as a result of the data input into the audit database program. These calculations are provided to show the method used to generate percent difference.

Q. Determine the true flow rate through the audit transfer standard orifice using Equation 2.

$$Qc = m \sqrt{\Delta P(H_2O) \ x \ (Ta/Pa)} + b \qquad \text{(Eq. 2)}$$

Where:

Qc = true volumetric flow rate as indicated by the audit orifice, ft^3/min. (CFM)
m = slope of the orifice.
$\Delta P(H_2O)$ = pressure change across the orifice, in inches of water H_2O.
Ta = ambient temperature in Kelvin.
Pa = ambient pressure in mm Hg or Kpa.
b = intercept of the orifice.

R. Determine the percent difference between the sampler actual flow rate and the corresponding audit measured true flow rate using Equation 3:

$$\% \text{ Difference} = \frac{[\ Qa - Qc\ ]}{Qc} \ x\ 100 \qquad \text{(Eq.3)}$$

S. Verify the true flow rate determined by the audit orifice is within the specified volumetric flow rate range of 1.1 to 1.7 m^3/min (39.0 to 60.0 CFM). If the true flow rate is outside the specified range, an Air Quality Data Action (AQDA) request is to be issued. Upon investigation, the invalidation or correction of all data from the last calibration forward or known date of change (to be determined by the reporting agency) may result.

T. Generate an audit report by entering the responses recorded into the database program (Figure D.1.2.3).

NOTE: If the TSP sampler is being utilized for lead analysis, enter the audit results into the computer using the lead data entry menu.

Figure D.1.2.1
Total Suspended Particulate (TSP) High Volume Sampler

QA AUDIT WORKSHEET
PM10 AND TSP

Site Name: ______________________ Site #: __________ Date: __________

Address: ______________________ Agency: ______________________

Technician: ______________________ Auditors: ______________________

Model: ______________________ ID#: __________ NAMS[ ] SLAMS[ ] PAMS[ ] SPM[ ]

Station Instrument Flow Rate				Audit Orifice DeltaP			
Run 1	Run 2	Run 3	Average	Run 1	Run 2	Run 3	Average

Cal. Date: __________ Magnehelic Reading: __________ EPA Equiv. Number: ____________ Collocated Yes[ ] No[ ] Passed FCT Yes[ ] No[ ]

Cal. Equip. Cert Date: __________ Slope: _______ Intercept: _______ Baro: _______ Temp: _____ °C

Model: ______________________ ID#: __________ NAMS[ ] SLAMS[ ] PAMS[ ] SPM[ ]

Station Instrument Flow Rate				Audit Orifice DeltaP			
Run 1	Run 2	Run 3	Average	Run 1	Run 2	Run 3	Average

Cal. Date: __________ Magnehelic Reading: __________ EPA Equiv. Number: ____________ Collocated Yes[ ] No[ ] Passed FCT Yes[ ] No[ ]

Cal. Equip. Cert Date: __________ Slope: _______ Intercept: _______ Baro: _______ Temp: _____ °C

Model: ______________________ ID#: __________ NAMS[ ] SLAMS[ ] PAMS[ ] SPM[ ]

Station Instrument Flow Rate				Audit Orifice DeltaP			
Run 1	Run 2	Run 3	Average	Run 1	Run 2	Run 3	Average

Cal. Date: __________ Magnehelic Reading: __________ EPA Equiv. Number: ____________ Collocated Yes[ ] No[ ] Passed FCT Yes[ ] No[ ]

Cal. Equip. Cert Date: __________ Slope: _______ Intercept: _______ Baro: _______ Temp: _____ °C

Air Resources Board
Quality Assurance Section

QA-PMTSP1
Revised 03/02

Figure D.1.2.2
QA Audit Worksheet PM10 and TSP

Technical Appendix - Mass Flow Controlled PM10

Station/Van Audit Data & Results

Van Data Pressure Drop (inches H2O)	Station Data Indicated Flows (CFM)	Actual Flows (CFM)	Average Indicated Flow (CFM)	Average Actual Flow (CFM)	**Percent Difference**
3.45	38.7	41.0			
3.45	38.7	41.0	39.4	41.0	*-3.9%*
3.45	40.7	41.0			

	Design Flows Lower Limit	Design Flows Upper Limit	**Percent Difference from Design**
Based on an actual flow of 41.0 CFM , the sampler **meets design criteria.**	36 CFM	44 CFM	*2.5%*

Audit Calculations

Actual Flow = BGI Slope * Squareroot (Pressure Drop * Ambient Temp in Kelvin / Ambient Pressure in mmhg) + BGI Intercept

BGI Slope = 33.7000 BGI Intercept = 1.7640

Ambient Pressure in mmhg = 757 Ambient Temp in Kelvin = 297.45

Instrument/AIRS Information

ARB Number	57582	AIRS Number	061131003
Audit Date	09/18/2002	Instrument Manf.	SA
Version	0	Model	1200
Quarter	3	Serial Number	L0015
Van	A	Last Calibration	04/17/2002

General Comments

California Air Resources Board
Monitoring and Laboratory Division
Quality Assurance Section

Figure D.1.2.3
QA Audit PM10 Report

Elevation vs. Altitude Correction Factor and Standard Flow Rate
TSP High Volume Sampler

Elevation (Feet Above Sea Level)	Altitude Correction Factor	Flow Rate Setpoint (SCFM)
0-999	1.000	45.0
1000	.965	43.4
1250	.956	43.0
1500	.947	42.6
1750	.938	42.2
2000	.930	41.9
2250	.921	41.5
2500	.913	41.1
2750	.904	40.7
3000	.896	40.3
3250	.888	40.0
3500	.879	39.6
3750	.871	39.2
4000	.863	38.8
4250	.855	38.5
4500	.847	38.1
4750	.840	37.8
5000	.832	37.4
5250	.824	37.1
5500	.817	36.8
5750	.809	36.4
6000	.802	36.1
6250	.794	35.7
6500	.787	35.4
6750	.780	35.1
7000	.772	34.7
7250	.765	34.4
7500	.758	34.1
7750	.751	33.8
8000	.744	33.5
8250	.737	33.2
8500	.731	32.9

Table D.1.2.1
Elevation vs. Altitude Correction Factor and Standard Flow Rate

D.1.3 AUDIT DATA REPORTING

The operating agency should be given a copy of the audit results when the audit is completed. If a sampler exhibits unsatisfactory agreement with the audit results (audit differences exceed ARB's control limits), the station operator needs to be informed and an Air Quality Data Action must be issued as soon as possible.

Deviations exceeding ±10% will require recalibration. Differences exceeding ±15% require an AQDA request to be issued. Upon investigation, the invalidation or correction of all data from the last calibration forward or known date of change (to be determined by the reporting agency) may result.

NOTE: Sections of the above procedures D.1.2 and D.1.3 were taken from the reference Method for Determination of Suspended Particulate Matter in the Atmosphere, Section 2.2.8, published by the Environmental Protection Agency.